

grade prepreg there will be a high performance fibre reinforcement combined with a complex polymeric resin matrix mix. This matrix mix normally consists of a thermosetting resin blended with various additives. These latter additives enhance the toughness of the basic resin. Such systems have complex flow characteristics and whilst they can be easily combined with fibres in a prepreg form, their use in other manufacturing techniques is limited. As for instance an attempt to use such a complex resin in an injection or resin transfer process in a complex fibre preform may result in the filtering out of additives and a non uniform product.

There is therefore a need for method of composite manufacture which overcomes the above mentioned problems particularly for large complex structures.

In accordance with a first aspect of the present invention there is provided a composite comprising a structural component and a resin component, the structural component comprising structural fibres and a toughening additive comprising non-structural thermoplastic fibres and the resin component comprising a non-thermoplastic material, and the structural component being a preform formed from the structural fibres and the thermoplastic fibres.

In accordance with a second aspect of the present invention, there is provided a structural reinforcement for use in a composite comprising a preform formed from structural fibres and non-structural thermoplastic fibres, wherein all or part of the structural fibres are combined with the non-structural thermoplastic fibres in the preform, and wherein the overall volume fraction of the structural fibres in the preform is at least 65%.

The term "structural fibre" as used herein refers to fibres which add to the strength of the ultimate composite such as glass or carbon fibres and which therefore have a modulus of elasticity greater than 50 GPa.

The term "non-structural fibre" as used herein refers to fibres which are not provided for increasing the strength of the ultimate composite as they

have a modulus of elasticity less than 20 GPa. Thus known strengthening fibres formed from materials such as Kevlar are not non-structural fibres within the terms of the present Application.

The form of the structural reinforcement enables removal of all toughening additives from the resins thus allowing use of low viscosity epoxy systems and so making impregnation of large parts feasible with sensible pressures, lightweight low cost tooling and manageable cycle times. Furthermore a significantly greater amount of toughening additive can be included without compromising any of the processability aspects of liquid composite moulding techniques.

Accordingly, in accordance with a third aspect of the present invention there is provided a method of manufacture of a composite comprising forming a preform from structural fibres with non-structural thermoplastic fibres to provide a structural component, injecting a liquid resin into the structural component, and curing the liquid resin component.

By incorporating the toughening additive into the structural component prior to addition of the resin, a lower viscosity resin may be utilised i.e. a resin substantially free of the toughening additive.

By toughening is meant the ability to increase the energy required to cause final fracture, which may manifest itself in the ability to absorb energy during impact. Such ability may be measured by suitable impact testing methods which will be known to the skilled man. Thermoplastic polymers are known to increase the ability to absorb impact energy in structural composites. By suitable formation of the preform they may be dispersed throughout the final composite to give homogenous impact resistance or introduced at specific locations to provide a zonal toughening mechanism as required in some composite parts.

Preferably, the toughening additive is a thermoplastic material whose latent heat of melting may absorb a proportion of exothermic curing energy but which, upon completion of curing, reverts to its solid form without loss of

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toughening capacity. Preferably, the curing agent, resin and thermoplastic additive are selected to provide a curing step which is at least partially carried out below the melting point of the said thermoplastic additive to thereby allow absorption of some of the energy of curing in the melting or phase change of the additive should excessive exotherm occur. Preferably, the curing step is commenced below the temperature of the melting point of the additive and may go above the temperature of the melting point during the curing cycle.

Injection of low viscosity resins (heated or otherwise) can decrease the injection-fill part of the processing cycle. However, it is also necessary to decrease the cure cycle time. This could be achieved by very active resins, higher temperature etc – but the risk is always the generation of an excessive exotherm – particularly in thick parts, which would lead to a degraded or damaged final part.

Preferably, the toughening additive comprises semi-crystalline thermoplastic fibres.

A very rapid cure can be affected without risking excessive exotherms if semi-crystalline thermoplastic fibres are used as the toughening additive. Heat generated by cure at an appropriate temperature can be used to generate crystalline melting within the fibres. The latent heat of crystalline melting will then moderate the temperature rise in the thermosetting resin. The selection of toughening fibres with appropriate crystalline melting temperature allows the cure cycle to be driven to its maximum potential without risk of composite damage. The semi-crystalline fibres themselves will simply revert to their original condition on cooling and the process will not affect the ultimate toughness of the parts.

Preferred toughening additives include:- polyethylene, polypropylene, polyamides, polyethylene terephthalate, polyether-ether-ketone.

Preferably, the toughening additive is sufficient to improve the impact energy of absorption of the untoughened composite by at least 30%, most preferably, by at least 50%.